MONITORING AND QUALITY ASSURANCE PLAN

for the

UPPER GREEN RIVER WINTER OZONE STUDY - 2010

Prepared for

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SECTION 1

INTRODUCTION AND PROJECT OVERVIEW

This monitoring and quality assurance plan provides the basis for the collection of air quality and meteorological data for the Upper Green River Winter Ozone Study (UGWOS) for the winter of 2010, sponsored by the Wyoming Department of Environmental Quality (WY DEQ). While research in nature, the monitoring methods and objectives described in this plan are consistent whenever possible with EPA quality assurance guidance for the collection of air quality and meteorological data (US EPA 2008a and 2008b) and the most recent guidance for the collection of meteorological data for regulatory modeling applications (US EPA, 2000).

Recent high ozone events observed in this area have raised concerns regarding potential adverse health and ecological effects associated with monitored concentrations greater than the U.S. Environmental Protection Agency's ozone standard (currently set at an 8-hour average concentration of 0.075 ppm[1]). Ozone formation in the Upper Green River Basin is unusual in that the highest concentrations have been recorded during the late winter and early spring (February to April) when sun angles are relatively low and temperatures are generally below freezing. This is in stark contrast to ozone exceedances in other areas, which occur during the warm summer months when abundant solar radiation and high temperatures act to increase precursor emissions and enhance the atmospheric reactions that result in ozone formation near the earth's surface (i.e., within the planetary boundary layer). Due to the pressing need to manage ozone air quality in the Upper Green River Basin and the limited amount of information currently available about the nature and causes of these unusual events, the WY DEQ funded a comprehensive field study (the Upper Green Winter Ozone Study or UGWOS) which was conducted during the late winter – early spring seasons of 2007, 2008, and 2009. While meteorological conditions unfavorable to ozone formation were encountered during the 2007 study period resulted in only limited monitoring, more favorable meteorological conditions during 2008 and to a lesser degree during 2009 resulted in several days of high ozone concentrations, including a large number of days when the 0.075 ppm Federal ozone standard was exceeded. Additional measurements have been planned for the winter of 2010. This QA plan addresses the 2010 monitoring effort.

[1] EPA is currently considering revisions to the ozone standard which would lower the level to somewhere between 0.060 and 0.070 ppm.

Data from the 2010 study will be used to refine a conceptual model of ozone formation developed on the basis of prior year'ss studies of ozone formation. The conceptual model will be used along with the field data to develop accurate meteorological and air quality numerical simulations of the ozone events. Both the conceptual and numerical models will in turn be used to develop effective air quality management strategies needed to adequately protect public health and the environment in accordance with applicable State and Federal laws.

SECTION 2

SAMPLING PROGRAM DESCRIPTION

The sampling period for UGWOS 2010 will run from January 15, 2010 through March 31, 2010. Sampling that will be conducted for UGWOS during this period is described below.

2.1 Forecasting Protocol

The UGWOS effort for 2010, in contrast to prior years, does not have an intensive operating period (IOP) component. However, the UGWOS team will continue to provide ozone forecasts throughout the study period to assist the WY DEQ in identifying potential high ozone periods. The current conceptual model of the meteorological conditions conducive to the formation of high ozone levels in the Pinedale-Jonah fields during the winter and early spring is characterized by mostly clear skies, light winds, extensive snow cover and a stable atmosphere. These conditions occur during periods when the synoptic weather is dominated by high pressure over the western Rockies, Intermountain area and the northern Great Basin. The primary broad scale characteristics dominating the Green River basin during the high probability events are weak pressure gradients within the context of a subsidence-dominated air mass.

In an effort to formulate the conceptual model, the synoptic scale weather patterns prior to occurrences of escalated ozone values in the study area during the winters of 2005 and 2006 were examined. Practical experience from the 2007, 2008 and 2009 studies has provided further understanding of conditions leading to higher ozone concentrations. Although many different nuances of the general pattern were encountered, the basic characteristics of the conceptual model did emerge. Figures 2-1 through 2-4 present composite views of the 700 mb and 500 mb configurations for all of the days with surface 8-hour averaged ozone concentrations greater than 60 ppb in 2004 through 2006. Figure 2-1 shows the ridging pattern of the 500 mb height contours; Figure 2-2 presents the wind speed isotachs at 500 mb; Figure 2-3 shows the ridging pattern of the 700 mb height contours; and Figure 2-4 demonstrates that there was warmer air aloft just above the surface, indicating air mass subsidence.

National Weather Service numerical synoptic-scale models such as the North American Mesoscale model (NAM) and the Global Forecast System model (GFS), coupled with regional NWS Forecast Discussion guidance, will provide the experienced MSI and T&B Systems weather forecasters with the basis for daily long and medium range operational forecasts. An additional factor that appears to prove critical in operational forecasting is the presence of sufficient

snow cover to provide the strong UV radiation flux and enhanced low level stability needed for development of high ozone concentrations. Local observations will provide this information on a day-to-day basis.

We will also be evaluating the usefulness of the Rapid Update Cycle model (RUC), the Weather Research and Forecasting model (WRF) and the RAMS model from CSU in our short-term operational forecasting mode and possibly incorporate them into our daily forecasts.

A forecast will be issued by 10 MST each day that will include both a short-term (days 1 to 3) and long-term (days 4 to 7) forecast. Quality control testing of equipment will be minimized on days of anticipated higher ozone concentrations in order to optimize data recovery.

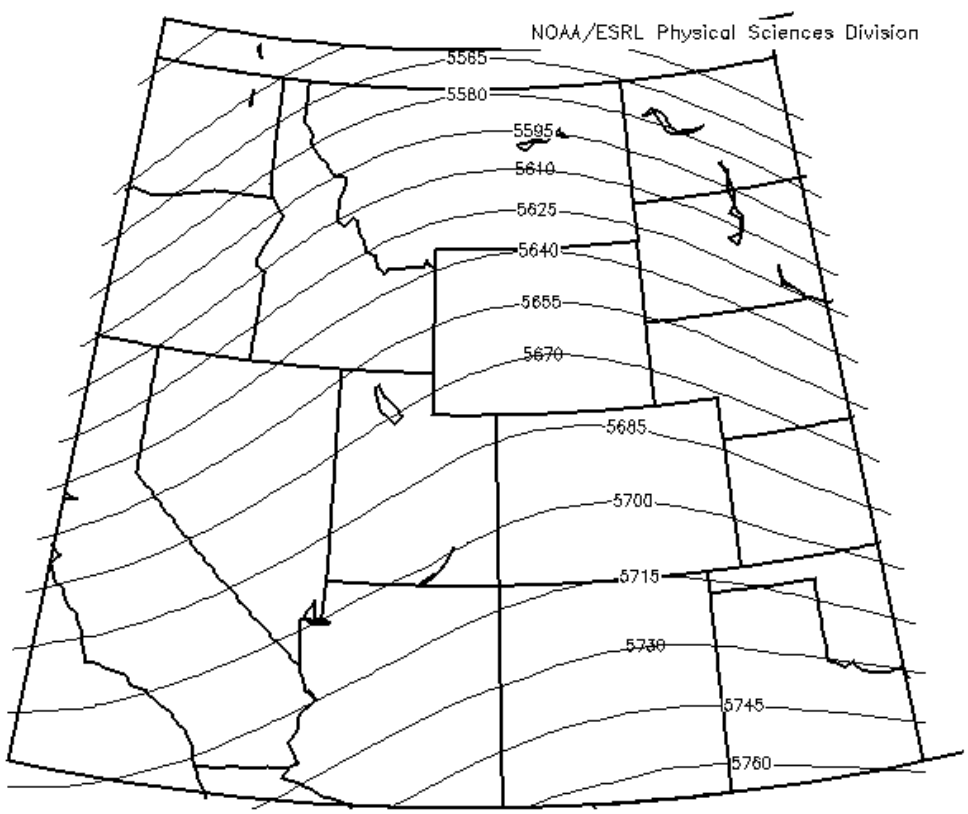

Figure 2-1 Composite 500 mb Heights During High Ozone Periods

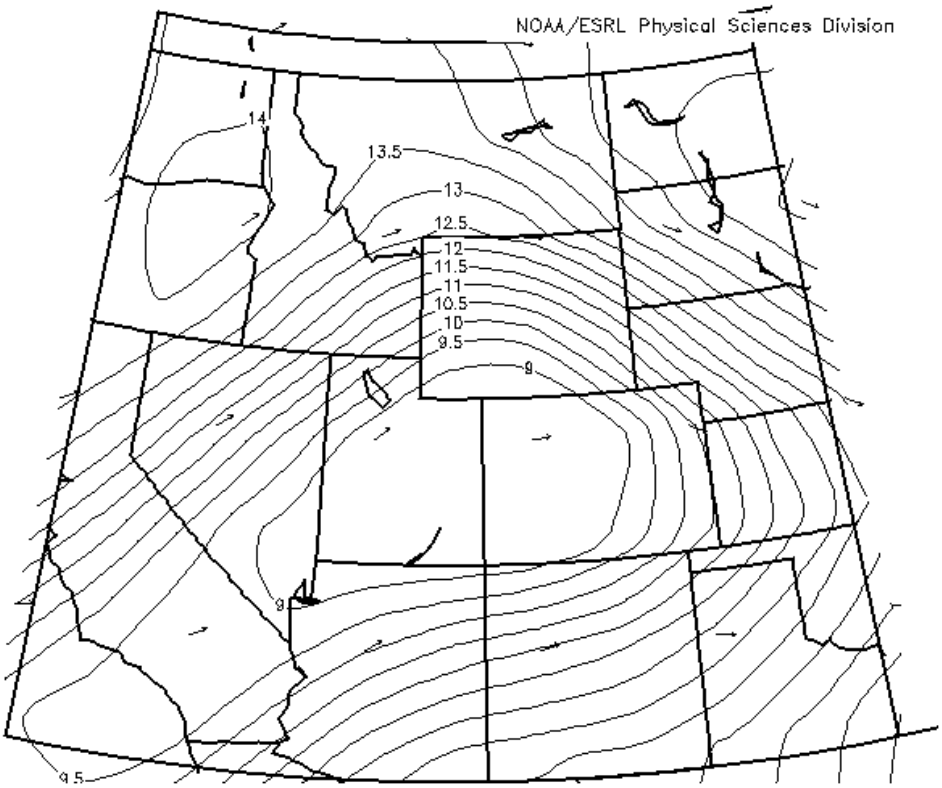

Figure 2-2 Composite 500 mb Winds During High Ozone Periods

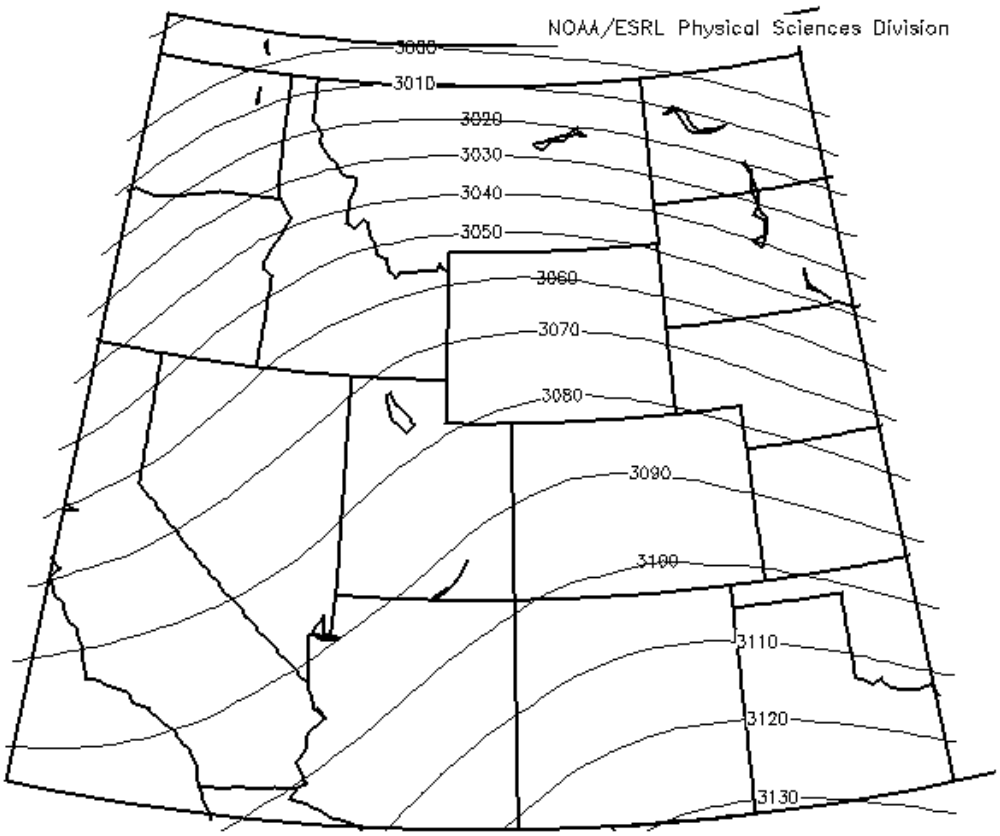

Figure 2-3 Composite 700 mb Heights During High Ozone Periods

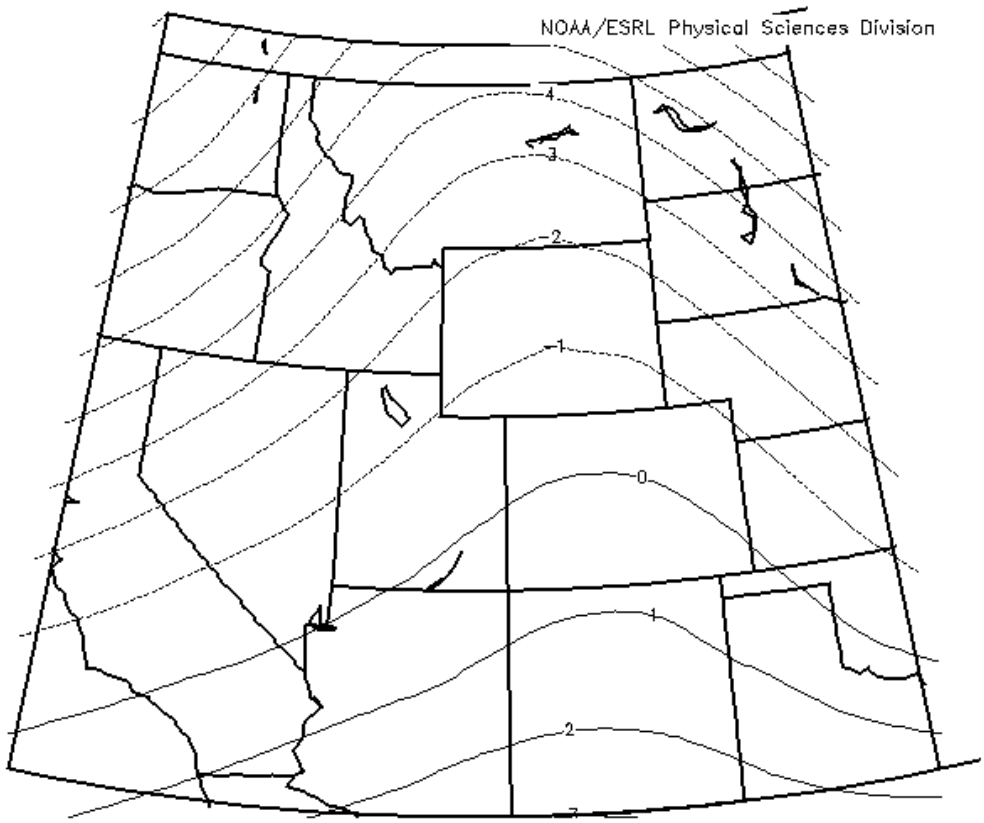

Figure 2-4 Composite 700 mb Temperature During High Ozone Periods

2.2 Continuous Measurements

Project-specific measurements to be continuously obtained over the complete field program period include surface and winds aloft, supplemental surface ozone and meteorology, and nitrogen species.

2.2.1 Mesonet Measurements

Surface ozone, wind, and temperature measurements will be taken from an 9-site mesonetwork (mesonet). All sites will be equipped with cellular telemetry, allowing remote polling and real-time review of data.

The mesonet ozone analyzers will operate continuously over the course of the study and routine performance checks of the analyzers will be conducted approximately once per week. Their operation on-site will be checked using the 2-B ozone generator and zero-scrubber, and any zero and span deviations

noted. An MSI air quality technician will be assigned to the project area for the duration of the 2010 measurement period to conduct the routine checks.

2.2.2 SODAR Upper Level Winds

For the 2010 monitoring effort, the WY DEQ MiniSodar (sodar) will be moved to the existing WY DEQ monitoring site at Boulder. Both surface and aloft winds will be measured continuously. The sodar is equipped with a battery bank, solar panels and a backup generator, providing continuous measurements without the need of AC power. However, the chosen site for operations does include available AC power. Remote communications is made possible with a cellular modem. All data will be posted near real-time on a web page as well as archived data posted automatically on a FTP server. These sodar data can be reviewed remotely, as necessary.

The WY DEQ will service the sodar as necessary. T&B Systems will review the data on a daily basis.

2.2.3 Nitrogen Species

The existing WY DEQ Boulder site will be expanded to included measurements of HONO. Dr. Bernhard Rappenglueck of the University of Houston will provide equipment and setup for the measurements. Routine checks of the equipment will for the most part be conducted remotely by University of Houston personnel, though MSI will be conducting regular visits to the Boulder site.

NO/NO_x measurements will be added to the existing mobile BAM $PM_{2.5}$ site operated by the WY DEQ, which will be located at the former WY DEQ Jonah monitoring site for the duration of the 2010 study. T&B Systems will provide the NOx analyzer. MSI will install and calibrate the analyzer and provide regular site checks.

2.3 Supplemental Monitoring and Data Collection

<u>UV Radiation</u>

Direct and reflected UV radiation sensors (radiometers) initially installed during the 2007 effort at the WY DEQ Boulder site will be an important part of the UGWOS data set. The sensors will be physically checked regularly throughout the study period by MSI, in addition to any checks conducted by the Boulder site operator (ARS).

Archiving of NOAA Products

Archiving of selected NOAA data products will occur on a daily basis. The items that will be archived for the period from January 15 through March 31, 2010 are listed below:

- MSI routinely archives 00Z and 12Z surface and upper air maps for 700 mb, 500 mb and 850 mb. (Also readily available from on-line archives)
- MSI routinely archives data from all rawinsonde sites in the United States for both 00Z and 12Z time periods. (Also readily available from on-line archives)
- MSI routinely archives Visual and IR, US east and west satellite images every 15 minutes. (Also readily available from on-line archives)

In addition to the above, the following data are currently archived on the web and available for analysis:

- Snowpack - available at NOAA's National Operational Hydrologic Remote Sensing Center
- Total Column Ozone - A web site from NASA provides historical ozone global charts, and Dobson Unit measurements for any lat/long on any particular day.
- Local Camera Images - The current local camera images from Daniel, Juel, Boulder and Pinedale can be viewed on line at the WY DEQ or UGWOS web sites, and there is also a 2 week image archive on the WY DEQ site which consists of an image at 9:00 12:00 and 15:00 MST each day. Archived images can also be requested from Air Resource Specialists, Inc. or InterMountain Labs.

SECTION 3

MONITORING SITE DESCRIPTIONS

Figure 3-1 presents a map of the UGWOS site locations. Tables 3-1 and 3-2 present coordinates and site selection rationale (monitoring objectives), respectively, for each of the sites. Photographs of the sites can be found in Appendix A.

Also included in Figure 3-1 and Table 3-1 are the locations of additional ozone monitoring sites in the study region. Specifically, five of the WY DEQ Air Toxics Network sites and four WY DEQ routine air monitoring sites monitor ozone. While not part of UGWOS study, data from these sites are anticipated to play a substantial role during the analyses of the UGWOS data.

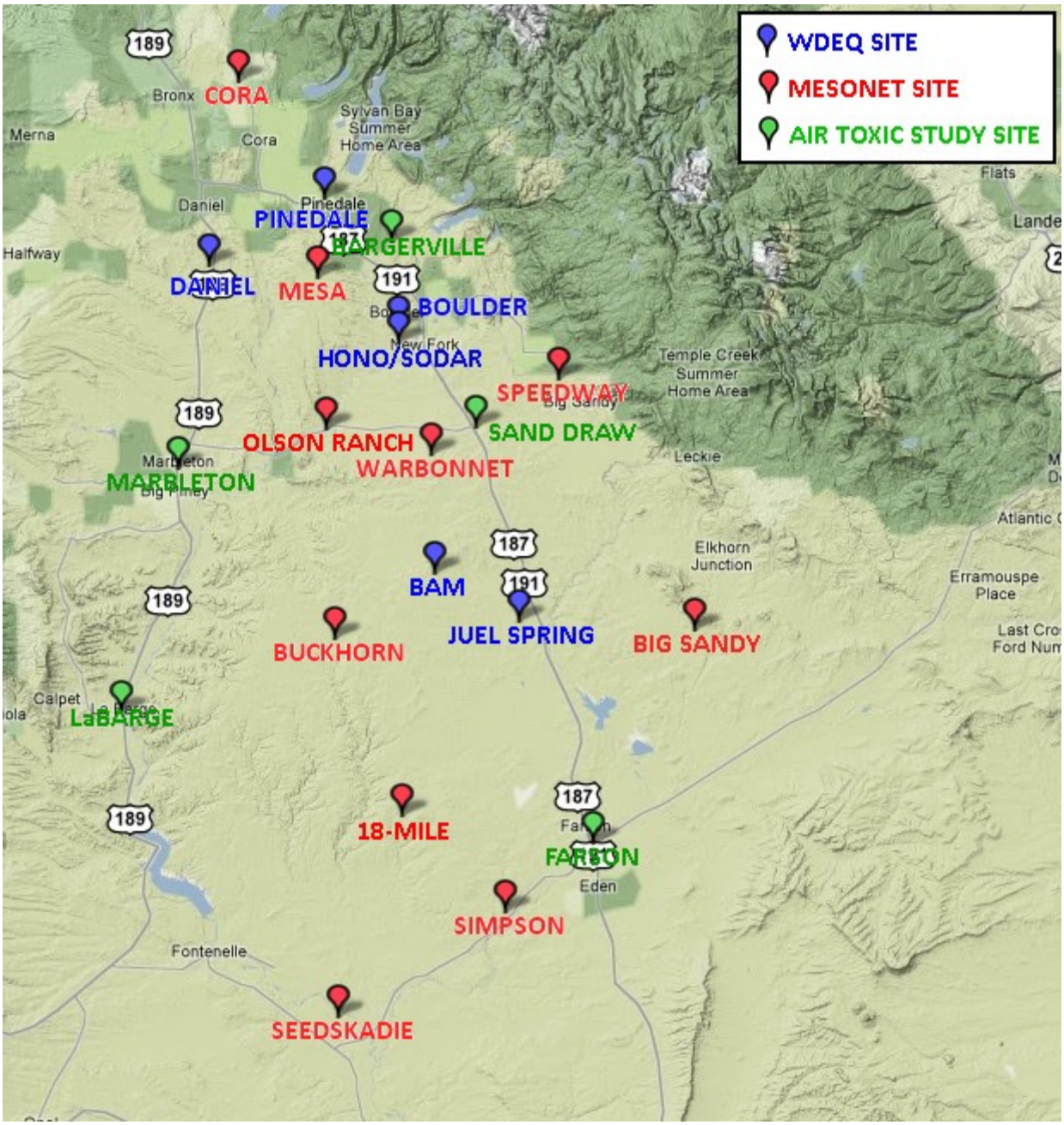

Figure 3-1. Map of UGWOS and Additional Ozone Monitoring Site Locations
Mesonet (red), WY DEQ / UGWOS (blue), Air Toxics Network (green)

Table 3-1. Network Locations and Identifiers

		Latitude	Longitude	Elev.
	MESONET SITES			
Site 1	18-mile Road	42.1438	-109.7491	6905’
Site 2	Big Sandy	42.3617	-109.2808	7112’
Site 3	Buckhorn	42.3523	-109.8543	7087’
Site 4	Cora	43.0065	-110.0088	7539’
Site 5	Mesa	42.7774	-109.8829	7522’
Site 6	Seedskadie NWR	41.9050	-109.8502	6315’
Site 7	Simpson Gulch	42.0280	-109.5819	6662’
Site 8	Speedway Pit (Big Sandy)	42.6573	-109.4983	7200’
Site 9	Warbonnet	42.5703	-109.70214	7397’
	SODAR / HONO SITE			
	Boulder	42.7188	-109.7529	7078’
	BAM / NOX SITE			
	Jonah BAM Trailer	42.4296	-109.6951	7108’
	ADDITIONAL MONITORING SITES OF INTEREST			
	Pinedale (WY DEQ)	42.8698	-109.8707	7186’
	Boulder (WY DEQ)	42.7188	-109.7529	7078’
	Juel Springs (WY DEQ)	42.4653	-109.5771	6848’
	Daniel (WY DEQ)	42.7910	-110.0650	7084’
	Bargerville (Air Toxics)	42.8200	-109.7653	7345’
	Sand Draw (Air Toxics)	42.6019	-109.6294	7235’
	Marbleton (Air Toxics)	42.5528	-110.1050	6915’
	La Barge (Air Toxics)	42.2642	-110.1947	6600’
	Farson (Air Toxics)	42.1100	-109.4428	6595’
	Castnet	42.9284	-109.7880	7853’

Table 3-2. Major Objectives of UGWOS 2010 Sites

Site 1	18-mile	Additional coverage between Buckhorn and Seedskadie
Site 2	Big Sandy	Southeastern boundary site
Site 3	Buckhorn	Representative of area SW of Jonah emissions
Site 4	Cora	Northern boundary site upwind from prevailing winds
Site 5	Mesa	Representative of northern Pinedale Anticline
Site 6	Seedskadie	Southern boundary site
Site 7	Simpson Gulch	Southeastern boundary site
Site 8	Speedway Pit	Impact on Wind River Range foothills
Site 9	Warbonnet	Representative of middle and southern Pinedale Anticline
	Sodar / HONO	WY DEQ Boulder site - Historic area of high ozone concentrations, collocated surface wind and NOx data
	BAM site	Old WY DEQ Jonah site - Ozone precursor emissions from the Jonah Field

SECTION 4

MONITORING EQUIPMENT DESCRIPTION

The following section describes the monitoring equipment that will be used for UGWOS. Monitoring quality objectives (MQOs) are presented for each of the monitoring methods.

4.1 MESONET OZONE MONITORING

All equipment used at the mesonet ozone monitoring sites will be housed in 70 to 100-quart insulated containers. Two 110 amp-hour deep cycle 12-Volt battery will power all equipment. Each site will be equipped with solar panels, allowing continuous monitoring and an Airlink Raven digital cellular modem for remote telecommunications.

The following equipment will be at each of the mesonet sites:

<u>2B Model 202 Ozone Analyzer</u>

The 2B Ozone Monitor will be used for the mesonet Monitoring. This monitor has a low power consumption (12v DC, 0.33 amp, 4.0 Watt) relative to conventional instruments allowing operation with deep cycle batteries. Additionally, it does not require a temperature-controlled environment. The 2B Technologies Model 202 Ozone Monitor™ is designed to enable accurate and precise measurements of ozone ranging from low ppb (precision of ~1 ppbv) up to 100,000 ppb (0-100 ppm) based on the well established technique of absorption of light at 254 nm. "Absorption spectroscopy" is a chemical analysis technique made possible by the phenomenon that a given molecule absorbs light at selected wavelengths. The wavelengths absorbed are characteristic of each molecule's atomic features. The amount of light radiation absorbed by a substance depends on two factors: the number of molecules in the path of the light, and the characteristics of the molecule (e.g., absorption cross-section). Measurement of changes in the light intensity as it passes through the molecules, and the use of calibration and reference data, enable the determination of the number of molecules encountered.

Accuracy (performance checks)	±5%
Precision (performance checks)	±5%
Resolution	0.001 ppm
Lower Quantifiable Limit	0.002 ppm

RM Young Model 05305 Wind Monitor AQ

For surface monitoring of wind speed and wind direction at the mesonet sites, we will employ RM Young 05305 Wind Monitor AQ wind speed and direction sensors. These sensors employ a propeller anemometer. The sensors will be mounted on 3-meter tripods (Figure 4-1), resulting in a measurement height of 3 meters. All sensors will be oriented to true north using either the GPS walk-off method or solar alignment method for orienting wind speed sensors.

Figure 4-1. Tripod mounting of wind sensors.

Monitoring quality objectives for the supplemental surface wind measurements are presented below.

Accuracy (instrument specifications)	
Horizontal Wind Speed	±(0.2 m/s + 5% of observed)
Horizontal Wind Direction	±5 degrees
Precision (performance checks)	
Horizontal Wind Speed	±0.1 m/s
Horizontal Wind Direction	±2 degrees
Output Resolution	
Horizontal Wind Speed	0.1 m/s
Horizontal Wind Direction	1 deg.
Starting Threshold	0.5 m/s

Campbell Scientific 109-L Temperature Probe

Ambient temperature will be monitored using a Campbell Scientific 109 temperature probe. The 109-L Temperature Probe is a thermistor designed for use specifically with the CR200-series data loggers and has a measurement temperature range of -50° to +70°C.

Accuracy (performance checks)	±0.5°C
Precision (performance checks)	±0.2°C
Resolution	0.1°C

Campbell Scientific CR206 Data Logger

All data will be stored using a Campbell Scientific CR206 data logger. Both 5-minute and 60-minute averages will be stored, though the 5-minute data will be used primarily for QC purposes. Based on the number of measurements and statistics being recorded, the CR206 can operate for a period of up to approximately two weeks before it is necessary to download data. The CR206 data logger is equipped with a 915 MHz radio, allowing remote accessing and downloading of data. Additionally, CDMA cellular modems will be used to retrieve the data via a real-time data connection with attempts every 15 minutes.

4.2 NITROGEN SPECIES MEASUREMENTS

NO/NO_x

The basic principle for measuring NO and NO_x is chemiluminescent detection (CLD) of NO. Sample air is reacted with ozone in a low-pressure reaction chamber. NO in the sample combines with ozone to form NO_2 and produces light (chemiluminescence) that is detected by a photo multiplier tube.

Ambient sample is first drawn through a very short Teflon sample line and split into two parallel flow channels using a ½ inch PFA Teflon tee. Channel 1 passes through a Teflon filter and then directly to the detector, while Channel 2 first passes through a catalytic converter before going through a Teflon filter to the detector. The catalytic converters reduce NO_2 to NO. Flow from each channel is alternately fed to the detection chamber to detect the NO. For NO_x, the converter is located within the analyzer.

Accuracy (performance checks)	±10%
Precision (performance checks)	±10%
Noise	0.0005 ppm
Lower Quantifiable Limit	0.001 ppm
Converter efficiency	>96%

HONO

The LOPAP (Long Path Absorption Photometry) instrument is described thoroughly in Heland et al. [2001] and Kleffmann et al. [2002]. It is a wet-chemical in situ instrument that consists of an external sampling unit where ambient gaseous HONO is directly sampled in a stripping coil using a mixture of sulfanilamide in hydrochloric acid. No sampling lines are used thus minimizing sampling artifacts on surfaces. The stripping reagent is transferred to the instrument where it is converted to an azodye by the reaction with N-naphthylethylenediamine-dihydrochloride. The absorption of the light from a white light-emitting diode is measured in long path absorption tubes made of Teflon AF2400 using a minispectrometer. In the external sampling unit, two stripping coils are used in series. In the first channel, HONO as well as possible interferences are determined, while in the second channel only the interferences are quantified. The difference of these two channels yields the HONO signal. The sampling time is between 1-5 min depending on the desired measurement range. The detection limit is about 1-2 pptv. The LOPAP instrument has been tested against DOAS measurements both in smog chamber studies as well as in field campaigns [Kleffmann et al., 2006].

Accuracy (performance checks)	±10%
Precision (performance checks)	±5%
Range	0.005 – 10 ppb
Detection Limit	1 – 2 ppt
Sample efficiency	>98%

4.3 REMOTE SENSING UPPER AIR METEOROLOGY

An ASC Model 4000 miniSodar will be used to collect the upper air meteorology data, providing vertically and temporally resolved boundary layer winds and boundary layer depth (i.e., mixing height) data. The system also includes a surface-based meteorological system. The Sodar provides continuous (hourly and 10-minute) wind data with a vertical resolution of 10 m at heights from about 20 m up to about 250 m agl. The exact height coverage at any given time depends on atmospheric conditions. Continuous (hourly or sub-hourly) boundary layer depth can be derived from the Sodar reflectivity data. An example of this is shown in Figure 4-4. The sodar will be operated under a configuration that produces the highest quality data for the typical atmospheric conditions found in the Upper Green River Basin.

Accuracy (instrument specifications)	
Horizontal Wind Speed	0.5 m/s
Horizontal Wind Direction	±5°
Maximum Altitude	250 meters
Sampling Height Increment	5 meters and greater
Minimum Sampling Height	15 meters
Transmit Frequency	4500 Hz.
Averaging and Reporting Interval	1 to 60 minutes

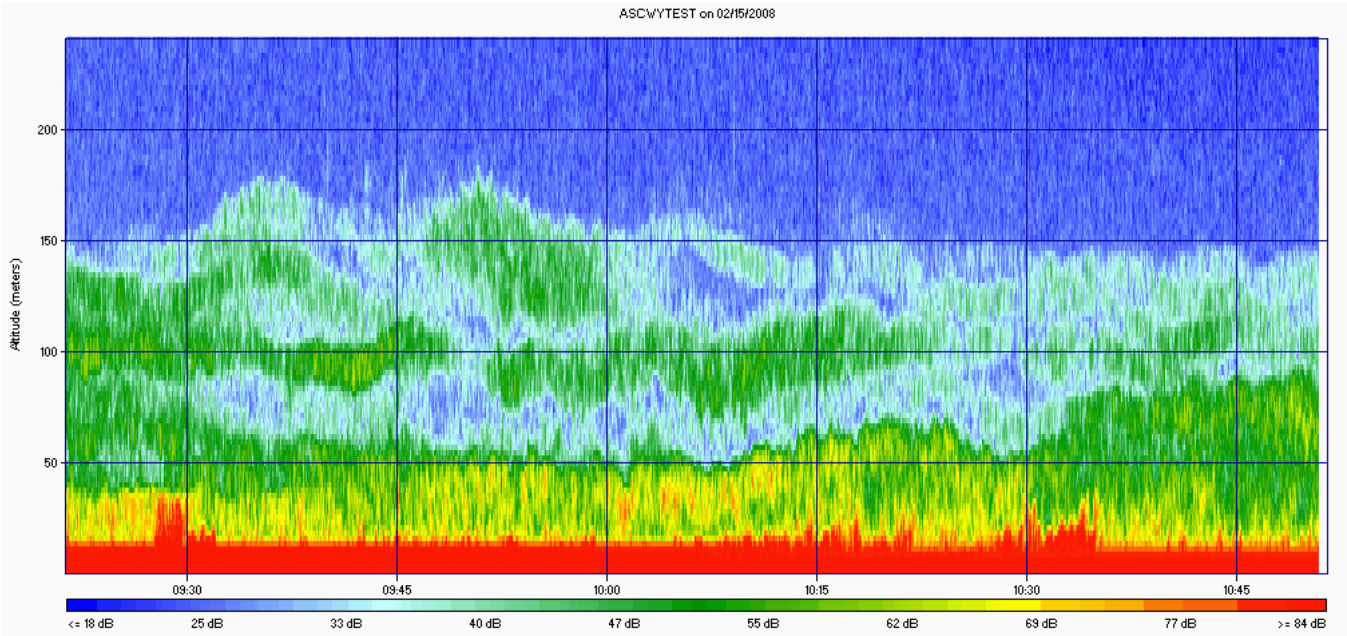

Figure 4-4. Example of sodar backscatter data capturing the daytime mixing height layers under cold wintertime conditions.

4.4 ADDITIONAL MEASUREMENTS

Total UV Radiation

UV radiation will be measured using two Eppley Total UV Radiation (TUVR) sensors – one facing upward to the sky and one facing downward to the ground. The Eppley Ultraviolet Radiometer consists essentially of a selenium barrier-layer photoelectric cell with a sealed-in quartz window, a bandpass filter to restrict the wavelength response of the photocell to the designed range, generally 295-385 nm (i.e. adhering closely to the generally accepted limits for solar ultraviolet radiation reaching the earth's surface, even at altitudes as high as 15,000 feet) and virgin Teflon diffusing disk. The purpose of this disk is twofold, - to reduce the light intensity at the filtered photocell (and thus to increase its stability with exposure time) and also to improve the adherence of the instrument to the Lambert cosine law (and is shaped with this object in view).

These sensors were installed at the Boulder site during the initial 2007 study and are currently being operated by Air Resource Specialists Inc.

SECTION 5

DATA REPORTING

5.1 DATA MANAGEMENT PLAN

A primary study objective is to produce an adequately validated data set from the field measurements that is well defined and documented, and available to researchers in a timely manner. The overall goal of the data management effort is to create a system that is straightforward and easy for users to obtain data and provide updates.

MSI will collect all measurements remotely on at least an hourly basis. Preliminary data will be posted on a near real-time basis on the UGWOS web site at http://www.metsolution.com/ugwos10/index.htm. Both 5-minute and hourly averages will be collected, though only the hourly averages will be reported. 5-minute data will be used to validate the hourly averages. The data loggers are all equipped with internal memory that can store data for the duration of the study. Thus, if telemetry fails at a given site, data can be collected manually. All polled data are backed up at least daily, minimizing the chance of data loss.

Each data provider will be responsible for reviewing and validating their collected data. The raw data will be validated to Level 1 as described in "The Measurement Process: Precision, Accuracy, and Validity" (Watson, 2001) before being submitted to the database. This includes flagging values for instrument downtime and performance tests, applying any adjustments for calibration deviation, investigating extreme values and applying appropriate flags. Flags used for UGWOS are presented in Table 5-1. Each data provider will be responsible for documenting the validation process so that it could be provided to the data manager and other analysts if needed.

In addition, each data provider will be responsible for furnishing information regarding the monitoring equipment used in the field study and any additional site information to the data manager as requested to enhance the overall documentation of the study. In particular, participants will provide the Monitoring Quality Objective (MQOs) defining the quality of all data submitted as "valid." These MQOs contain the following:

- Accuracy
- Precision
- Lower quantifiable limit
- Resolution
- Completeness

If cases exist where data do not meet the primary MQOs but is still deemed useable and can be defined with a secondary set of MQOs, these additional MQOs and the dates to which they apply will also be submitted.

Flag	Description
V	Valid. Data meets primary MQOs.
S	Valid, but does not meet primary MQOs. Secondary MQOs in effect.
I	Data invalid.
M	Missing. Measurement not taken.

Table 5-1. Data Flags.

Once the data have been validated to Level 1, the data will be prepared for submittal to the database in a form that clearly define the time reference, averaging period, parameter names and units. The time reference for the database is **local standard time (Mountain Standard Time)** and the averaging period reference will be standardized to **hour beginning (0 – 23)**. The data will be submitted as ASCII comma delimited text files or excel spreadsheet files, with data columns well defined to clarify site identification, parameters, instrumentation, units, and time reference.

Data will be submitted in a format similar to that of the final database structure, as outlined below. This basically has a second column for each measured value for an accompanying QC code. Data flagged as invalid or missing will be given a value of -9999. In the event that data for a given measurable is either all valid (meeting primary MQOs) or all missing, participants need not supply the flag column, though this must be specifically stated.

Database Management Design

MSI will be responsible for assimilating the submitted data into an integrated relational Microsoft ACCESS database and is managing the data for subsequent distribution and analysis. The database will consist of both information and data files. The goal is to make the database very usable by data analysts and all participants.

The following describes the design for the database, which was similarly implemented during the 2007, 2008 and 2009 field studies. The database includes an inventory spreadsheet file to help users track and ensure that all of

the data were submitted and processed in a timely and consistent manner. All data files submitted will be examined to verify unique names for all sites, instruments, and parameters so that no orphan or duplicate records exist in any of the tables. A system is in place for identifying the version and or modification date of all data files. All files are backed up daily.

The data have the following flat format:

Surface Hourly Meteorological Data

SITE, DATE, HOUR, WS, WS_QC, WD, WD_QC, TP, TP_QC, and any additional met parameters and QC codes, if collected.

Ozone 8-hour averaged:

SITE, DATE, HOUR, O3_8HR, O38HR_QC

Hourly Surface Air Quality:

SITE, DATE, HOUR, OZONE, O3_QC, NO, NO_QC, NOx, NOx_QC, NOy, NOy_QC, PAN, PAN_QC and any additional air quality parameters if collected and QC codes.

Upper level meteorological and air quality data

SODAR data will be stored in both a flat file format and a CDF (common data format) or similar tabular format. CDF files are used for plotting the data. Participants should include both flat files and CDF files with their data submissions. The final flat format will be as follows:

SITE, DATE, HOUR, TIME, HEIGHT, WS, WS_QC, WD, WD_QC

The data will be formatted into the final database with the following unit configurations and naming conventions:

- Parts per billion (ppb) for O3, NO, NO_2, and NOx
- Parts per trillion for HONO
- Meters per second for wind speed (as a general rule, metric units will be used)
- Degrees Celsius for ambient temperature
- Watts/m^2 for radiation

- SITE = Alpha-numeric site code identifier
- DATE = (MM/DD/YY)
- HOUR= Nearest whole begin hour (HH) (MST)
- TIME, START_TIME or END_TIME = Time stamp of data (HH:MM:SS) (MST)
- HEIGHT = Elevation in meters above MSL
- QC_CODE, WS_QC, WD_QC, O3_QC, etc =

"V" (valid), "M" (missing), "I" (invalid), "S" (secondary MQOs)

- NOTES = any additional information

The Level 1 data files along with the documentation files will be available for download on an FTP server.

5.2 DATA REPORTING

Files of all data collected during the study will be transmitted to WY DEQ by June 15, 2010.

The team will review the validated data collected during the field study and prepare descriptive summaries in a report format for delivery to WY DEQ. The Team will prepare summaries of air quality and meteorological conditions during the study period. In addition, the Team will prepare more detailed descriptive analyses of the air quality and meteorology measured during any high ozone events during the study period. As part of the Level 1 data validation procedures, the Team will carefully examine all of the measurements. This process typically provides insight into the critical processes that determine the extent of pollution loading such as atmospheric stability, wind shear (low-level jets, etc), layers aloft, and boundary layer development (growth rate, peak mixing heights), including the nocturnal boundary, convective boundary, and residual layer. The meteorology leading up to and during periods with high ozone levels and the diurnal behavior of ozone aloft during these periods will be characterized.

Supporting the analyses discussion, products that will be produced in this phase of the study include but are not limited to:

1. Time-series plots of continuous measurements such as ozone, ambient temperature, radiation;
2. Vertical profiles of winds;
3. Horizontal mapping of ozone, precursors, ambient temperature, and winds—both at the surface and aloft;
4. Time-height cross sections of ozone, winds, and mixing heights;
5. Time-height cross sections of transport statistics including scalar transport distance, vector transport distance, and recirculation factors;
6. Wind roses at the surface;
7. Pollution roses at the surface; and
8. Summary tables of 1-hour and 8-hour averaged ozone as well as statistical summaries showing hourly averages and maximums.

A final report will be prepared presenting:

- The above-mentioned information and associated analyses in an easy to comprehend format.

- A summary of field operations. A measure of the associated data capture rates will be included. Problems encountered during the field operations will be discussed.
- Details of the database design including descriptions of the metafiles; field descriptors; and the accuracy, precision, lower limits, resolution, and completeness of each measurement.

A draft version of the report will be presented to WY DEQ by August 31, 2010. Voluminous tables and figures will be incorporated into electronic appendices as appropriate. All report materials will be made available via a project web site with access restricted in accordance with WY DEQ policies and procedures.

SECTION 6

QUALITY ASSURANCE PROGRAM

6.1 PROJECT MANAGEMENT

Mr. George Wilkerson will serve as overall project manager. Mr. Bill Hauze will serve as the Field Operations Manager for the study. He will be responsible for coordinating and verifying corrective action for any measurement-related problems.

Study personnel responsibilities and contact information is presented in Table 6-1.

A UGWOS study web site has been developed to assist in communications between study participants and to display real-time data. This web site can be found at http://www.metsolution.com/ugwos10/index.htm. Operational status of all UGWOS equipment can also be viewed at this site.

While it is not anticipated that the scope of the monitoring effort will change over the relatively short duration of the effort, any changes will result in a revised version of this QAPP. Mr. David Bush is responsible for the writing and distribution of the QAPP. Revisions will be distributed based on the distribution list at the beginning of this document.

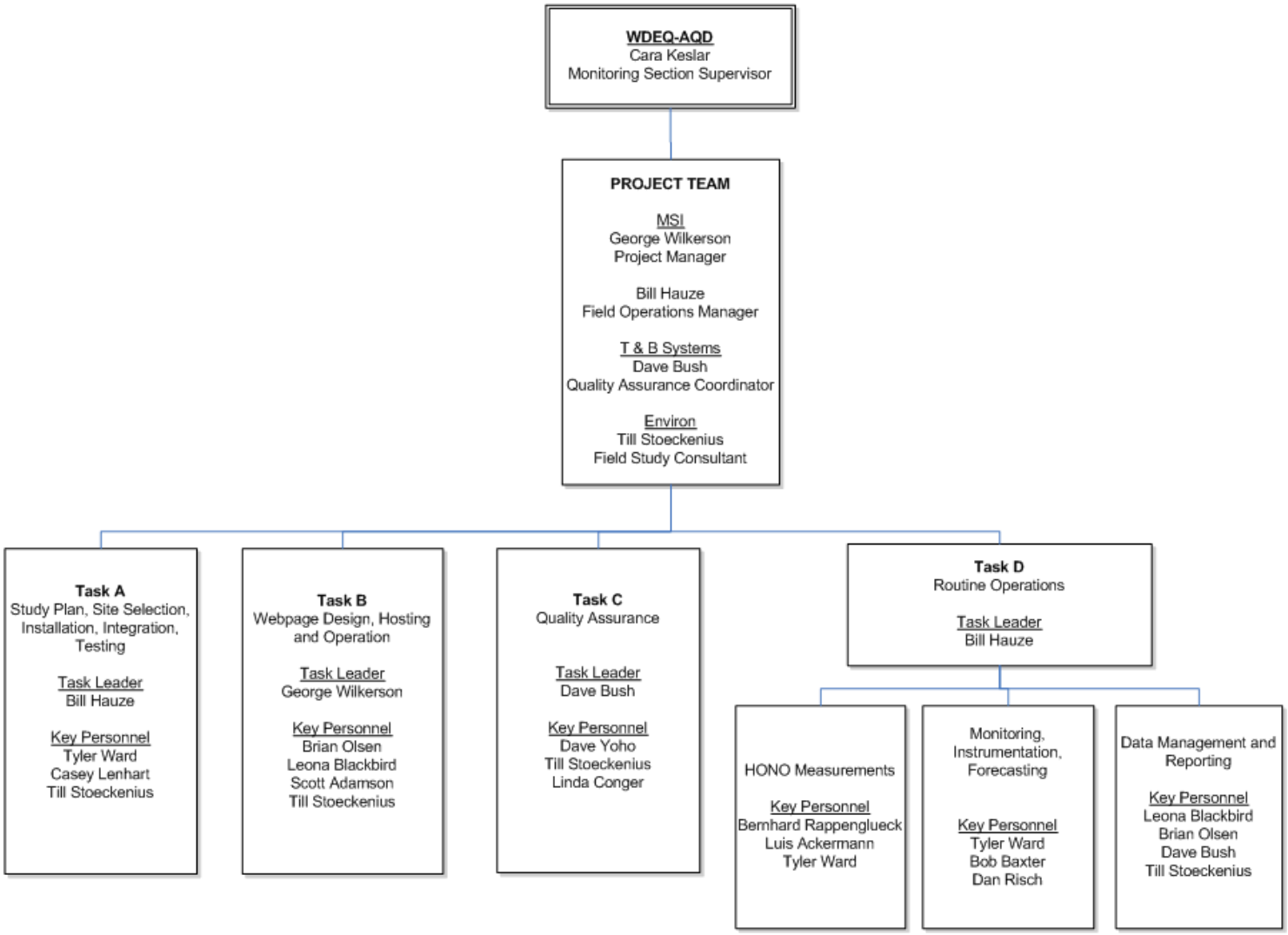

Figure 6-1. Project organization.

Table 6-2. Project Responsibilities and Contacts

Name	Organization	Key Responsibilities	Phone Numbers
Cara Keslar	Wyoming DEQ	Contract Manager	(307) 777-8684 (307) 421-9953 (cell)
Jennifer Frazier	Wyoming DEQ	Pinedale support Daniel site operations	(307) 231-2387 (cell)
George Wilkerson	MSI	Project Manager	(801) 272-3000
Bill Hauze	MSI	Field Manager	(801) 272-3000 (801) 450-3776 (cell)
Dan Risch	MSI	Forecasting	(801) 272-3000
Leona Blackbird	MSI	Data polling Data processing and validation	(801) 272-3000
Tyler Ward	MSI	Full-time onsite field support Mesonet Site Checks	(928) 814-3926 (cell)
David Bush	T&B Systems	Quality Assurance QAPP	(530) 647-1169 (530) 903-6831 (cell)
Bob Baxter	T&B Systems	Measurements support Sodar operations	(661) 294-1103 (661) 645-0526 (cell)
Bill Knuth	T&B Systems	Forecasting	(707) 279-1661 (707) 975-4413 (cell)
Till Stoeckenius	Environ	Data analysis and reporting	(415) 899-0709 (415) 717-0039 (cell)
Bernhard Rappenglueck	University of Huston	HONO measurements	(713) 743-1834
Luis Ackermann	University of Huston	HONO measurements support	(832) 396-8501
Lincoln Sherman	ARS	Boulder Site Operations Air Toxic network	(970) 222-5362

6.2 DATA QUALITY OBJECTIVES

Specific monitoring quality objects have been presented for each measurement in Section 4 of this document. The overall objectives for the collection of valid data will be as follows:

Air quality data: 80% of the possible data

Meteorological data: 90% of the possible data

For the above calculation, data lost during calibrations, maintenance or audits are considered invalid.

6.3 ASSESSMENT AND OVERSIGHT

QUALITY CONTROL PROCEDURES

As part of the quality assurance program, detailed quality control procedures have been implemented to assess and maintain control of the quality of the data collected. All equipment will undergo complete checkout and acceptance prior to the start of monitoring on January 15, 2010. This checkout will occur during the week prior to the start of monitoring, as well as during setup and installation of the equipment. Standard operating procedures (SOPs) for measurements will be completed prior to the start of monitoring. SOPs can be found in Appendix B.

A summary of key elements of the QC program for each measurement is presented below:

<u>Ozone Analyzers</u>

All ozone analyzers and samplers will be routinely checked using a certified transfer standard, following operating procedures consistent with EPA guidelines. This will consist of zero and span checks conducted approximately weekly. For FEM ozone analyzer, these checks will be conducted using a transfer standard certified against a primary standard maintained following EPA's guidelines at MSI's office in Salt Lake City, UT. For the mesonet equipment, a 2B model 306 (S/N 2) portable ozone calibrator will be used. This portable ozone calibrator will also be compared regularly against MSI's primary standard. A pass/fail criterion of +/-10% will be used when evaluating the span and calibration data, after which corrective measures will be implemented.

<u>MiniSodar</u>

The status of the instruments will be checked daily via remote access of the data. If any problems are encountered that could affect data recovery, repairs will be made promptly. The data will be transferred hourly to T&B's server, using a cellular modem. Data can also be accessed in real time via a web site so that team members can use the data to assist in special monitoring and forecasting. The link to the web site is: http://tbsys.serveftp.net/ugwossodar/.

NO/NOx

Zero/span checks of the analyzer will be conducted periodically using a certified standard. A pass/fail criterion of +/-10% will be used when evaluating the span and calibration data.

HONO

The instrument is calibrated by exchanging the sample stripping reagent with a nitrite standard (Merck, Titrisol) diluted in the stripping solution, while running under zero air. Concentrations are calculated using the concentration of the liquid standard and the measured liquid and gas flows. Zero air measurements are automatically performed in regular intervals by a second flow controller and a magnetic valve. The zero air is injected by a small PFA line directly into the inlet of the stripping coil. Zeroes are conducted every 8 hrs for 20 minutes. Calibrations are done once every 8 days or after replacing tubings or reagents, whatever occurs earlier.

CALIBRATIONS

The purpose of a calibration is to establish a relationship between the ambient conditions and an instrument's response by challenging the instrument with known values and adjusting the instrument to respond properly to those values. The calibration method for each of the air quality and meteorological variables is summarized in Table 6-3.

Calibrations of the ozone instruments and the NO/NOx analyzer will be performed upon initial installation and at the end of the study period. Additional calibrations will be performed on an as-needed basis in the event of equipment repair or replacement. All calibrations will be performed in accordance with manufacturers recommendations and consistent with USEPA guidance (USEPA, 1994, 1995, 2000).

Calibrations and zero/span checks of all ozone monitoring equipment will be conducted using a transfer standard (2B Model 306, S/N 002) certified against a local ozone standard. This local standard in turn has been certified against MSI's primary standard maintained following EPA's guidelines at their office in Salt Lake City, UT, as well as against the US EPA Region 8 primary standard maintained at Boulder, CO.

Ozone data will be adjusted if the calibration slope is off by more than ±5% or if the zero is off by more than ±5 ppb.

The NO/NOx analyzer will be calibrated using a certified dilution calibrator and a certified gas standard. Standard gas phase titration (GPT) methodologies will be used for calibration of NO_2 channels.

All meteorological sensors will be calibrated at the beginning and end of the study. Wind speed sensors will be calibrated using an RM Young constant rpm motor simulating wind speeds at several points across the sensor's operating range. Wind direction sensors will be calibrated by checking responses in a least

90° increments. Temperature sensors will be calibrated using a water bath and a certified thermometer. Calibration of the UV radiometers is provided by the manufacturer.

Table 6-3. Calibration methods for the monitored variables.

Measurement Variable	Calibration Method
Ozone (O_3)	Multipoint comparison of ozone concentrations with ozone transfer standard
NO/NOx	Multipoint comparison of concentrations against a dilution of a certified gas standard
Wind Speed	Rotational rate using a selectable speed anemometer drive
Wind Direction	Alignment using true north and linearity with a directional protractor
Temperature	Water bath comparisons to a certified transfer standard

INDEPENDENT AUDITS

As part of the quality assurance program, an independent audit program will be implemented that will use an independent entity to verify the site operations and data accuracy. These audits will be performed using personnel independent of the measurement program. This will establish confidence in the data collected and allow the measurement processes to be supported through independent verification. Audits will be performed in accordance with the principles of the US EPA.

System audits will be conducted of all data collection operations. System audits will address the following:

- Siting
- Adherence to SOPs
- QA/QC procedures
- Documentation
- Data collection and chain of custody

In addition to the system audits, performance audits will be conducted at the mesonet sites and of the UGWOS-specific nitrogen oxide measurements. Performance audits will be conducted using equipment and standards independent of those used in the field.

At the mesonet sites, wind speed sensors will be audited using an RM Young constant rpm motor simulating wind speeds at several points across the sensor's operating range. Wind direction sensors will be audited by checking responses in 30° or 45° increments. Temperature sensors will be audited using a water bath and a certified audit sensor. The ozone monitors will be audited using an ozone transfer standard that is certified against T&B's primary standard

maintained following EPA's guidelines at their office in Valencia, CA. T&B's ozone standards were certified on January 7, 2010 against the EPA Region 9 primary photometer located at their laboratory in Richmond, CA.

The UGWOS-specific nitrogen oxide measurements will be audited using a certified dilution system and a certified cylinder of NO.

Mr. David Bush will conduct the audits of all measurement platforms, with the exception of the nitrogen oxide analyzer, which will be audited by David Yoho. These audits will be conducted near the beginning of the study, after the continuous measurements have become operational. Comments and recommendations resulting from the audits will be discussed with measurement personnel at the time of the audit, with a written memo report provided to study management within 48 hours of the audit. Mr. Bush will work with Mr. Hauze to verify that any deficiencies noted during the audit are addressed.

6.4 DATA VALIDATION

All data collected for UGWOS will be validated to Level 1 validation (see Section 5). As part of the validation effort, participant's data will be evaluated to verify that they meet the stated MQOs. If data clearly do not meet MQOs, they will be removed from the database as invalid data. If, however, data miss meeting the primary MQOs in a definable way to the point where the data are still considered useful, secondary MQOs will be assigned to the data in question. This use of secondary MQOs will be specifically documented in metafiles associated with the data.

SECTION 7

REFERENCES

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APPENDIX A

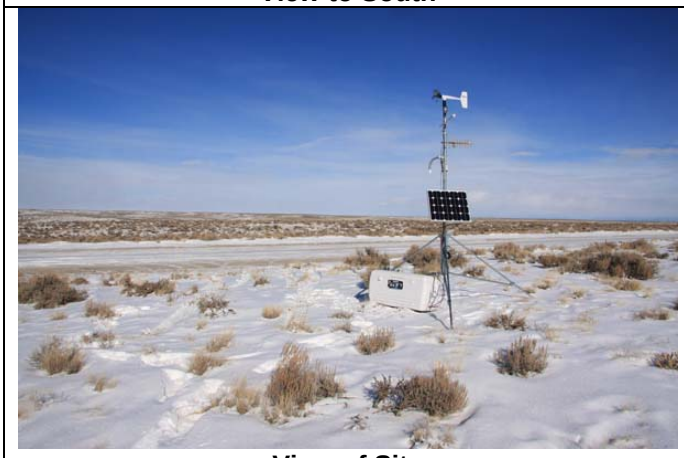
SITE PHOTOS

View to North

View to East

View to South

View to West



View of Site

18-mile Road

View to North

View to East

View to South

View to West

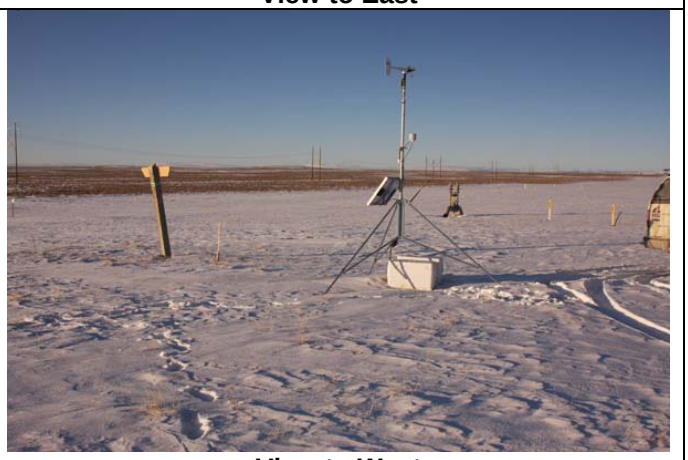
View of Site

Big Sandy

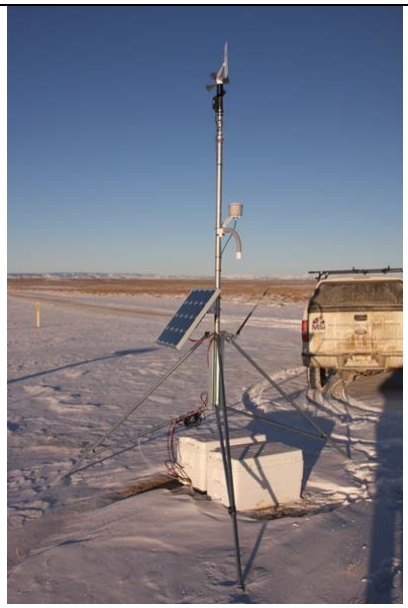
View to North

View to East

View to South

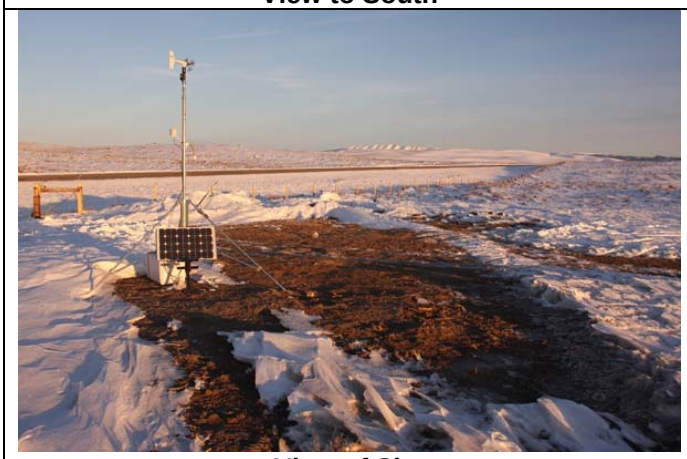


View to West



View of Site

Buckhorn

View to North	View to East
View to South	View to West
 View of Site	

Cora

View to North

View to East

View to South

View to West

View of Site

Mesa

View to North

View to East

View to South

View to West

View of Site

Seedskadie

View to North

View to East

View to South

View to West

View of Site

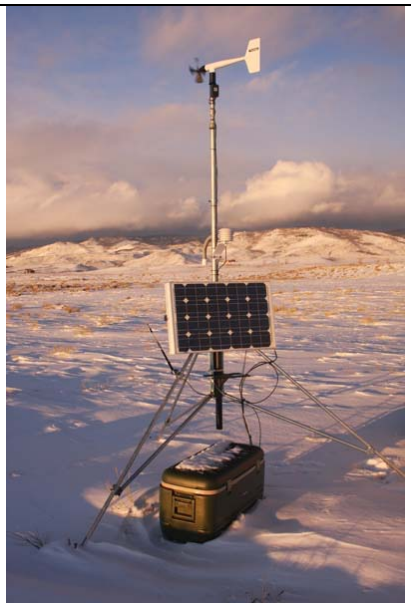
Simpson

View to North

View to East

View to South

View to West

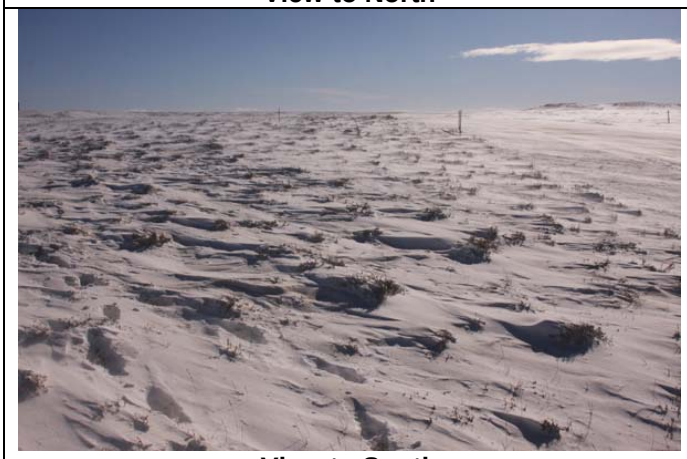


View of Site

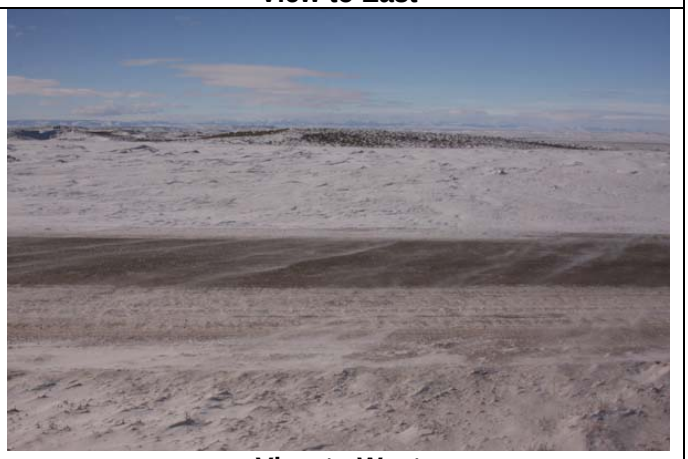
Speedway

View to North

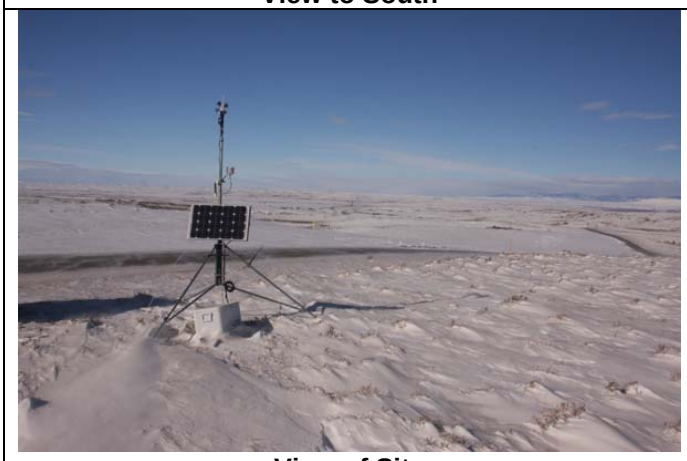
View to East



View to South

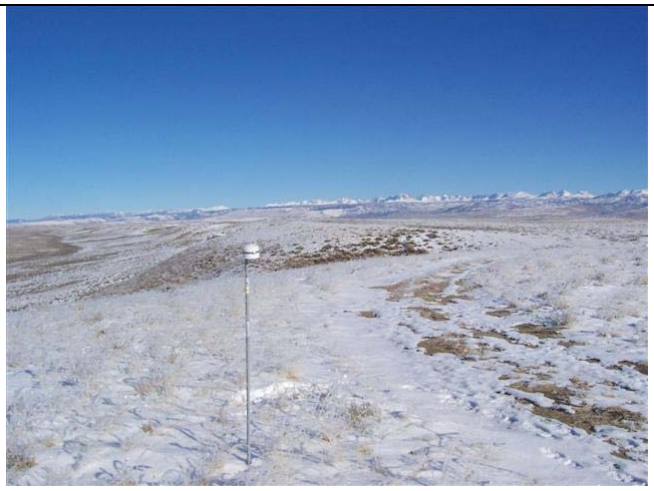


View to West



View of Site

Warbonnet



View to North

View to East

View to South

View to West

View of Sodar V path (SW)

View of Sodar U path (NW)

MiniSodar and HONO (Boulder) Site

View of MiniSodar	**HONO inlet with Mini Sodar in Background**

MiniSodar and HONO (Boulder) Site

View to North	View to East
View to South	View to West
View of Site	

BAM PM2.5 and NOx (Old Jonah Site)

APPENDIX B

STANDARD OPERATING PROCEDURES

Appendix B
ACCESS Database Description